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Cheng

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(54) **MANUFACTURING METHOD OF PACKAGE CARRIER**

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(Continued)

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CPC ***H01L 23/13*** (2013.01); ***H01L 23/3677*** (2013.01); ***H01L 23/49822*** (2013.01); ***H05K 1/0204*** (2013.01); ***H05K 3/427*** (2013.01); *H01L 2224/48091* (2013.01); *H01L 2224/48227* (2013.01); *H01L 2224/73265* (2013.01);
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See application file for complete search history.

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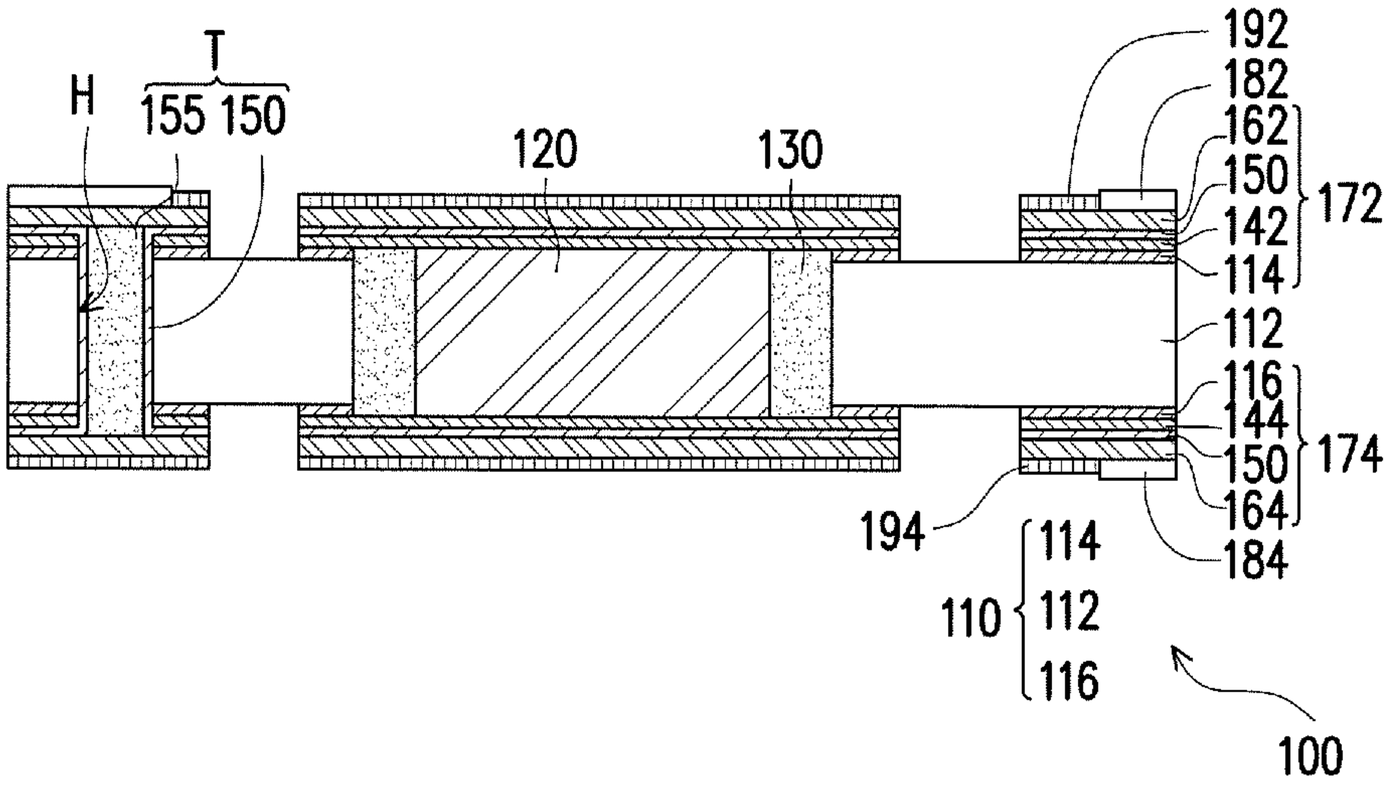
(57) **ABSTRACT**

A manufacturing method of a package carrier is provided. A substrate having a through hole is provided, wherein a profile of the through hole from top view is a first rounded rectangular. A heat conducting slug is disposed inside the through hole, wherein the heat conducting slug and an inner wall of the through hole are separated with a gap, and a profile of the heat conducting slug from top view is a second rounded rectangular. An insulating material is filled in the through hole so as to fix the heat conducting slug in the through hole. A conductive through hole structure, a first and a second patterned circuit layers are formed. The first and the second patterned circuit layers are respectively formed on two opposite sides of the substrate. The conductive through hole structure penetrates the substrate and connects portions of the first and the second patterned circuit layers.

6 Claims, 9 Drawing Sheets



(51) **Int. Cl.**

H01L 23/498	(2006.01)
H05K 1/02	(2006.01)
H05K 3/42	(2006.01)
H05K 3/02	(2006.01)

(52) **U.S. Cl.**
CPC ... *H05K 3/022* (2013.01); *H05K 2201/10416* (2013.01); *H05K 2203/0191* (2013.01)

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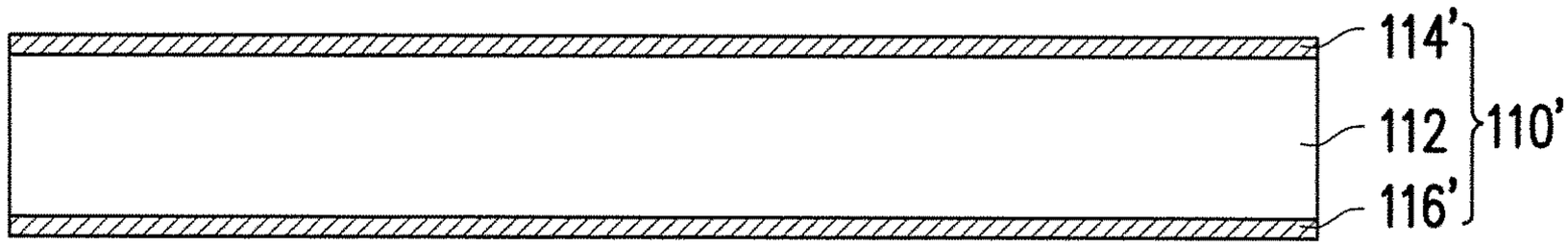

FIG. 1A

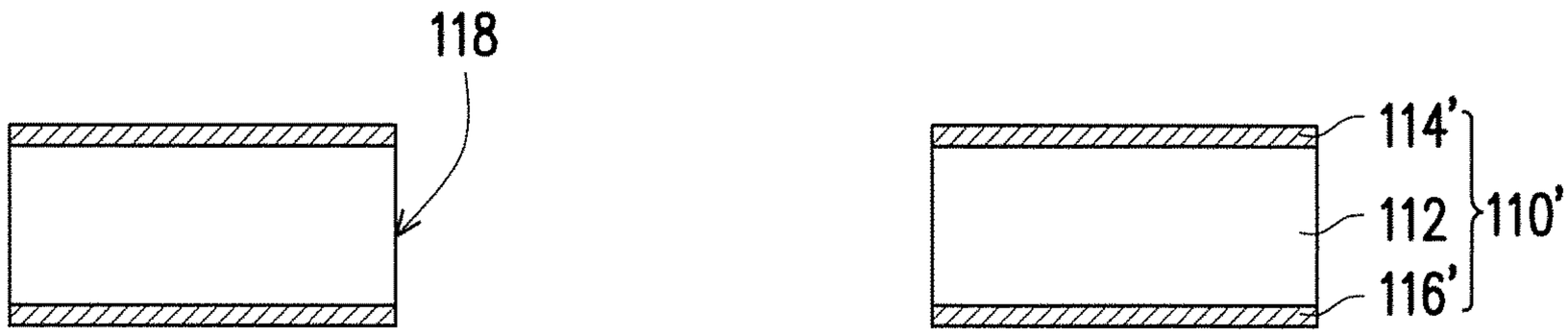

FIG. 1B

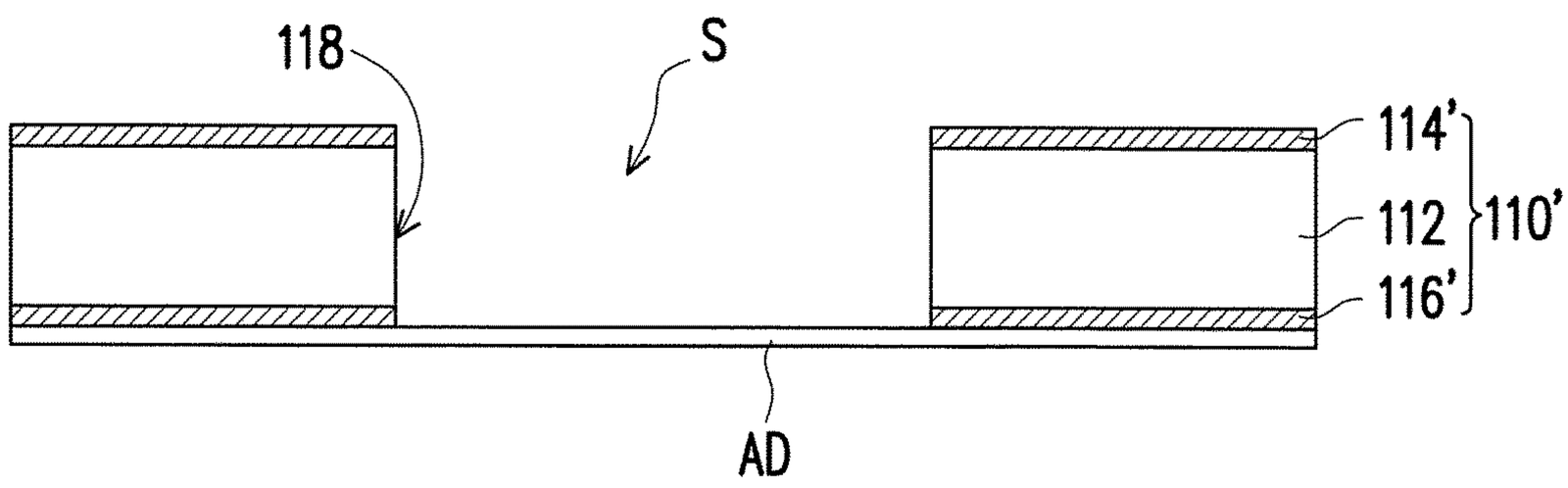

FIG. 1C

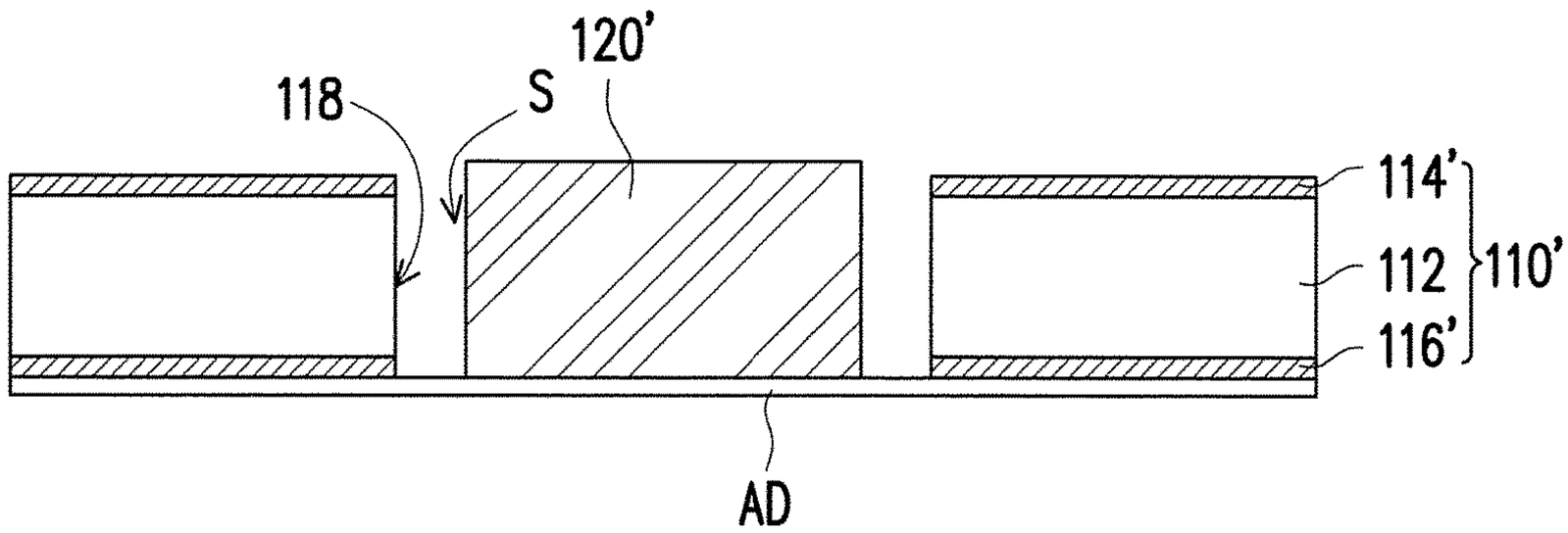

FIG. 1D

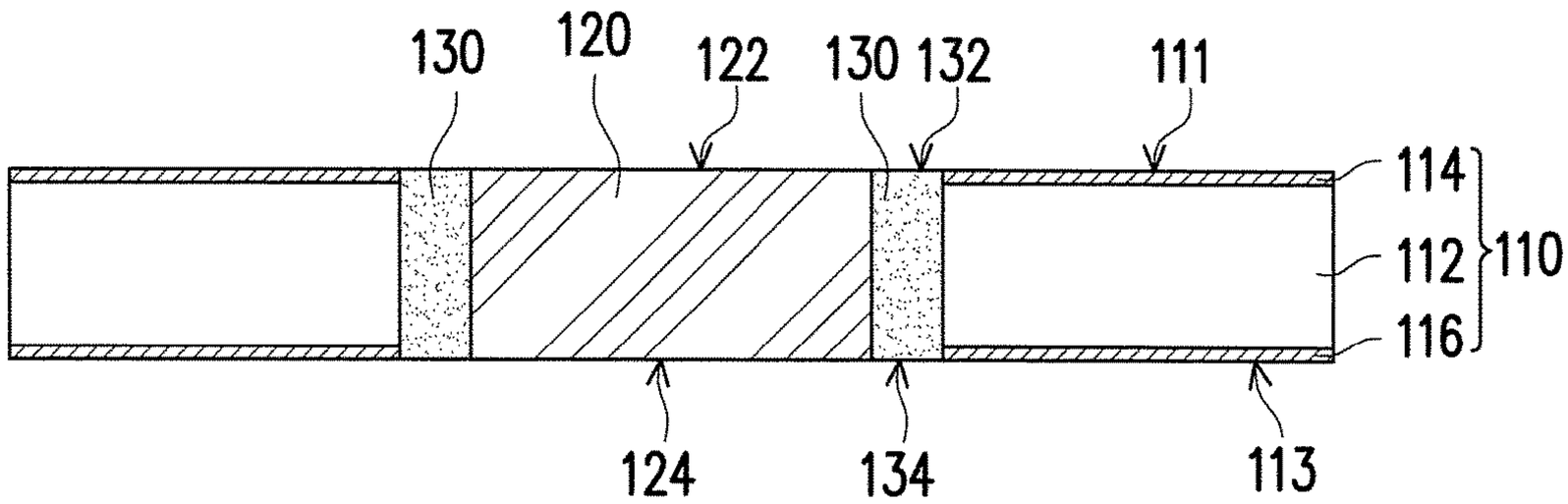
130
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FIG. 1E

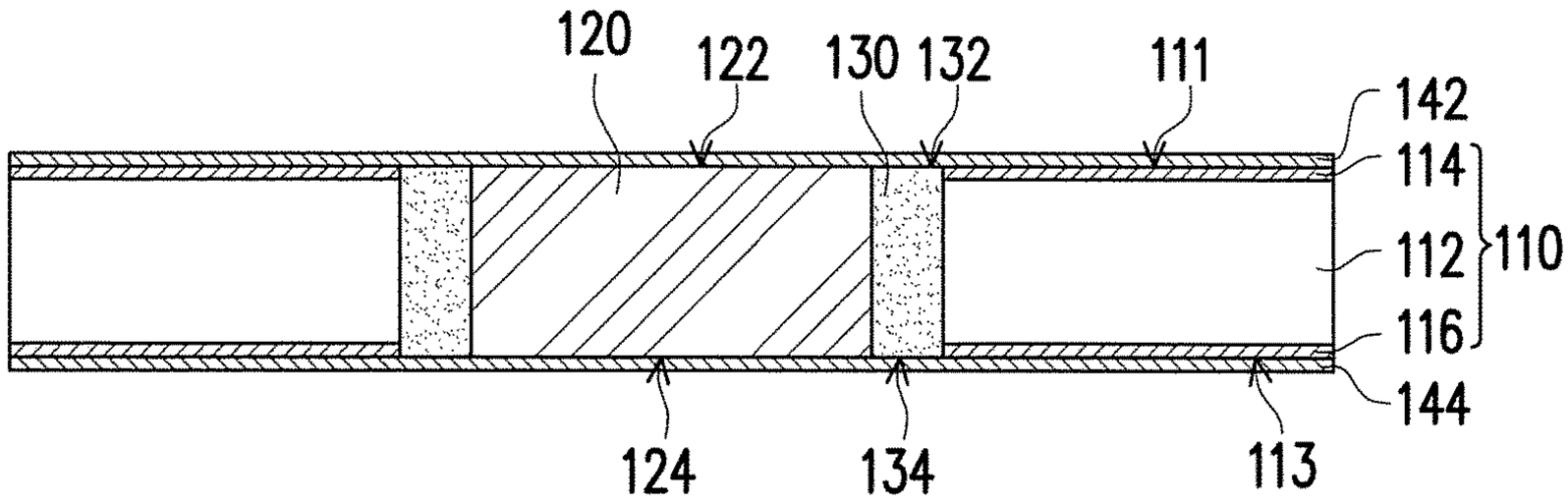
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FIG. 1F

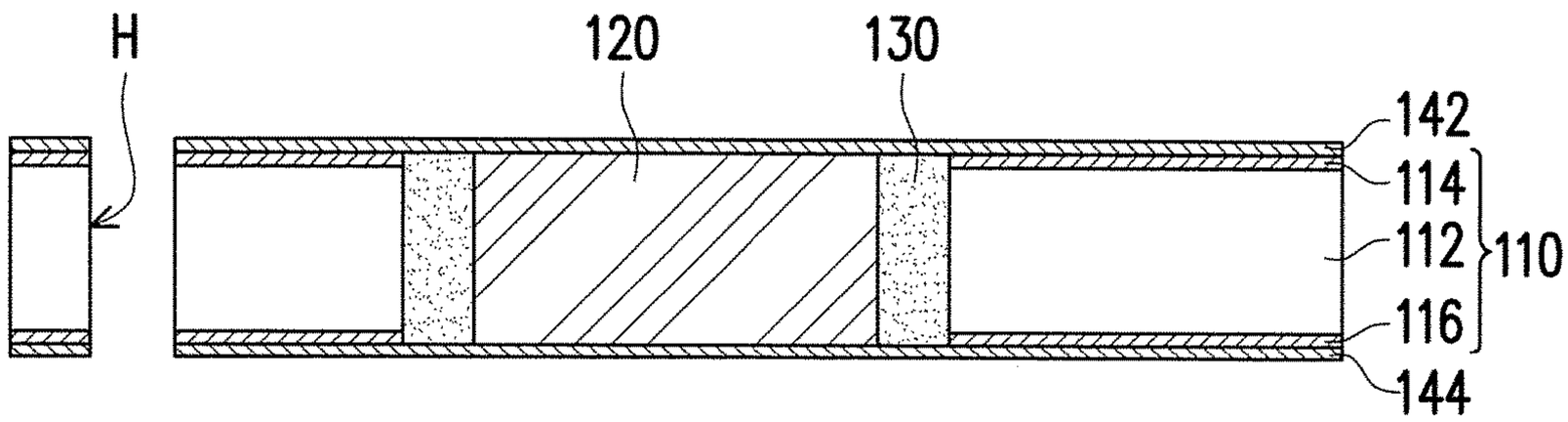
H
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FIG. 1G

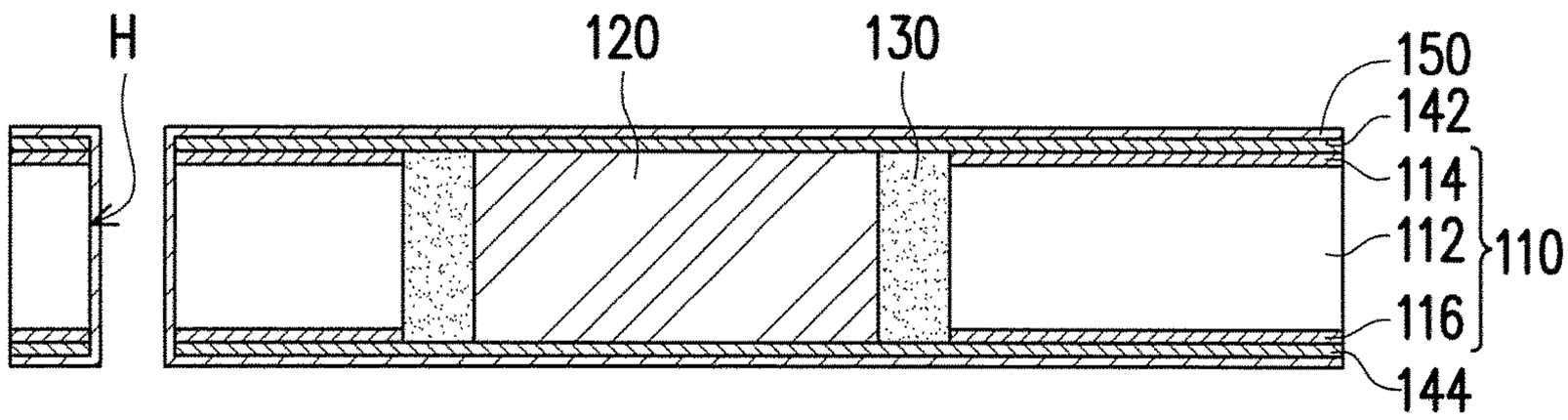
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FIG. 1H

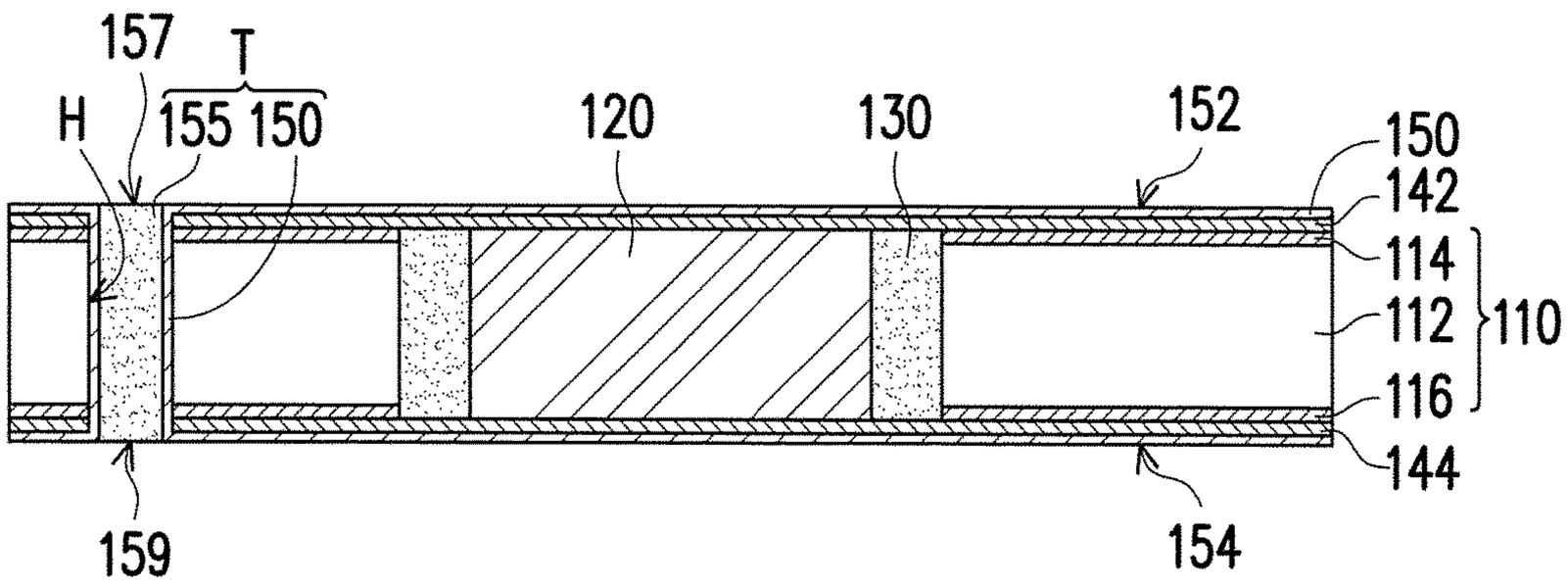
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FIG. 1I

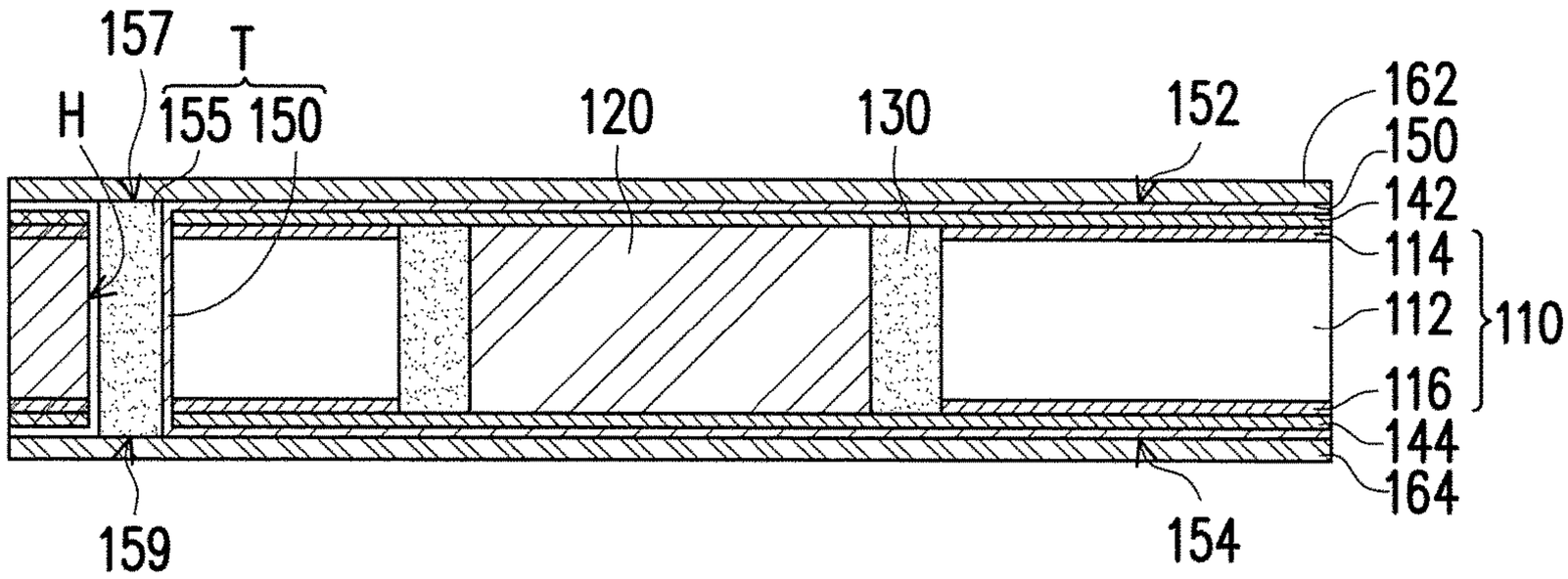
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FIG. 1J

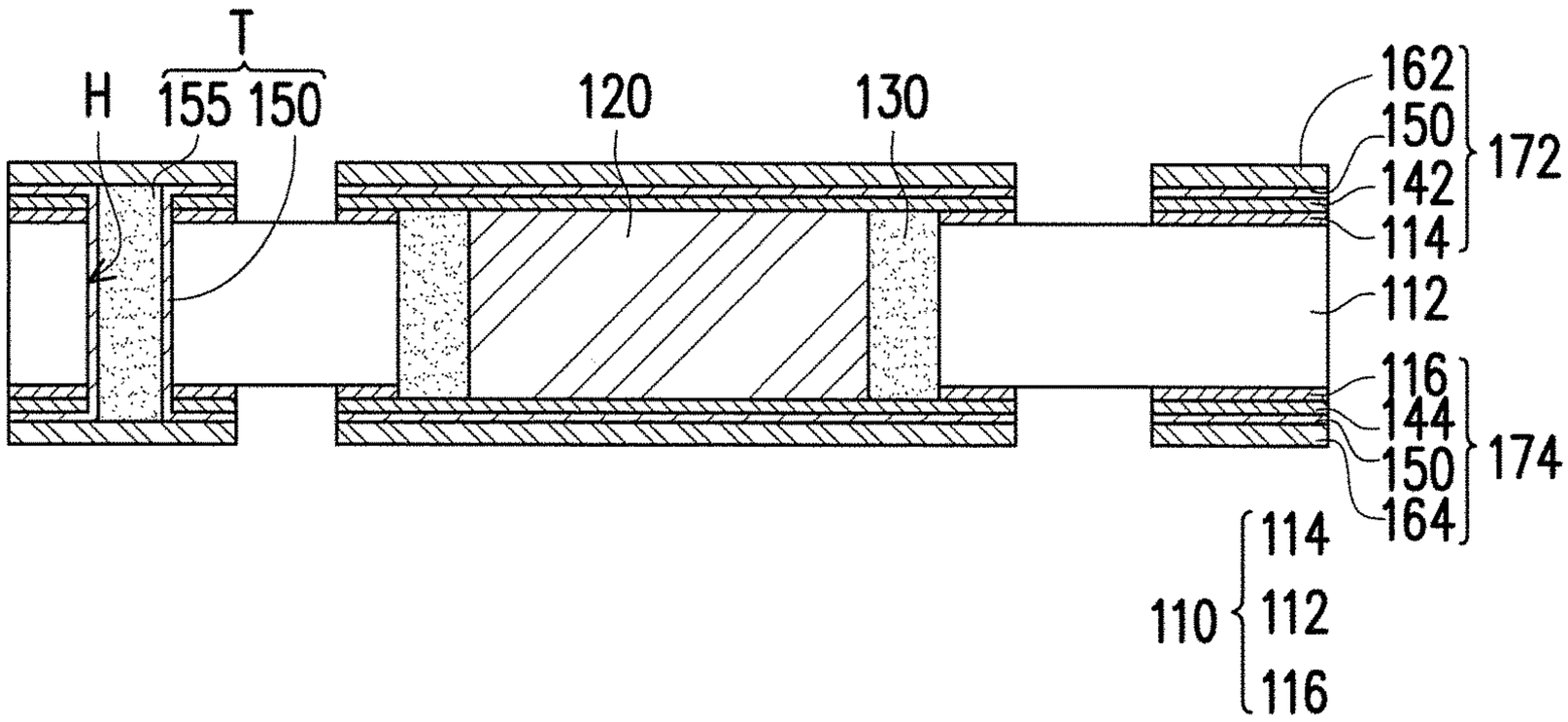
T
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FIG. 1K

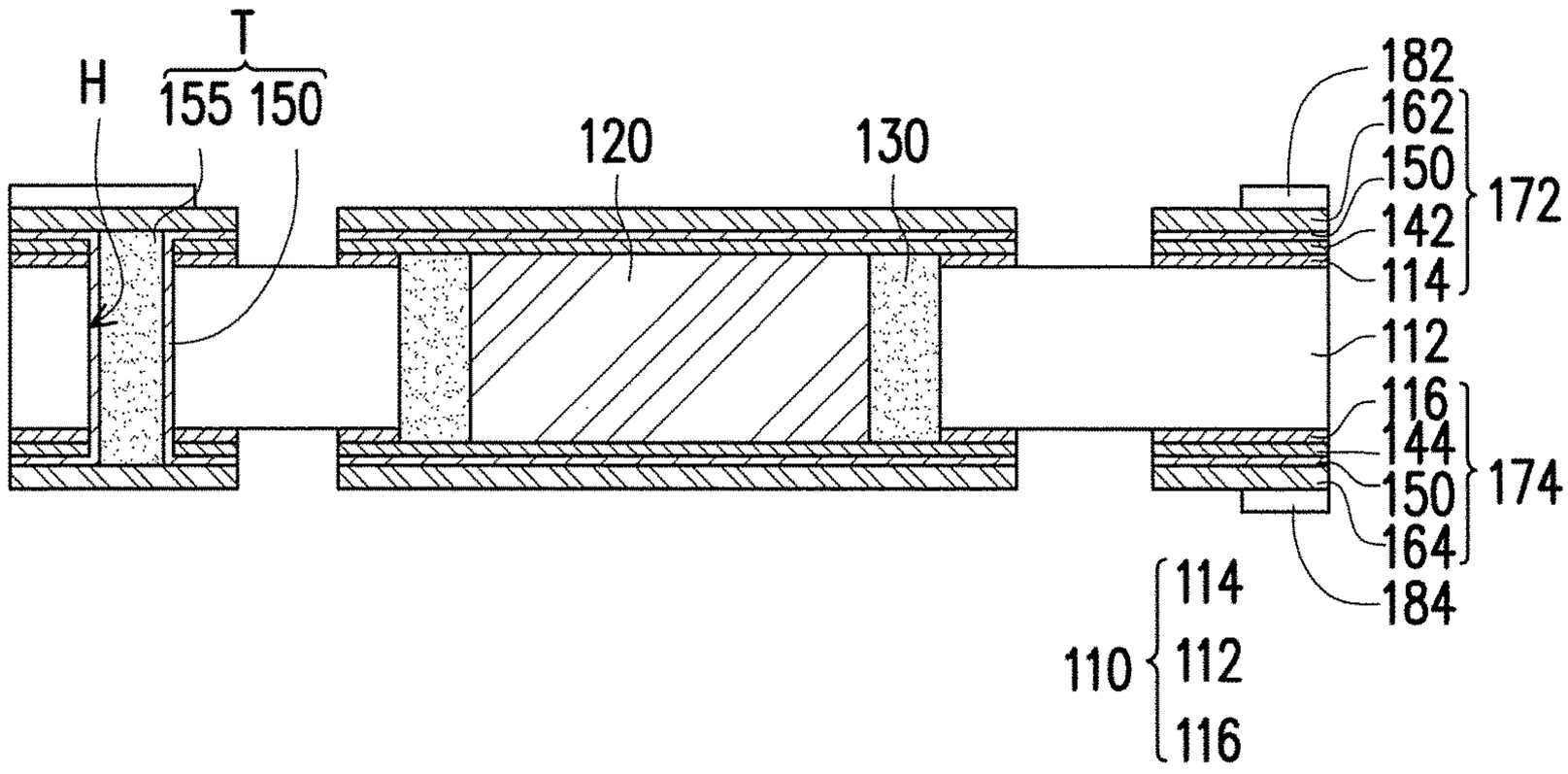
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FIG. 1L

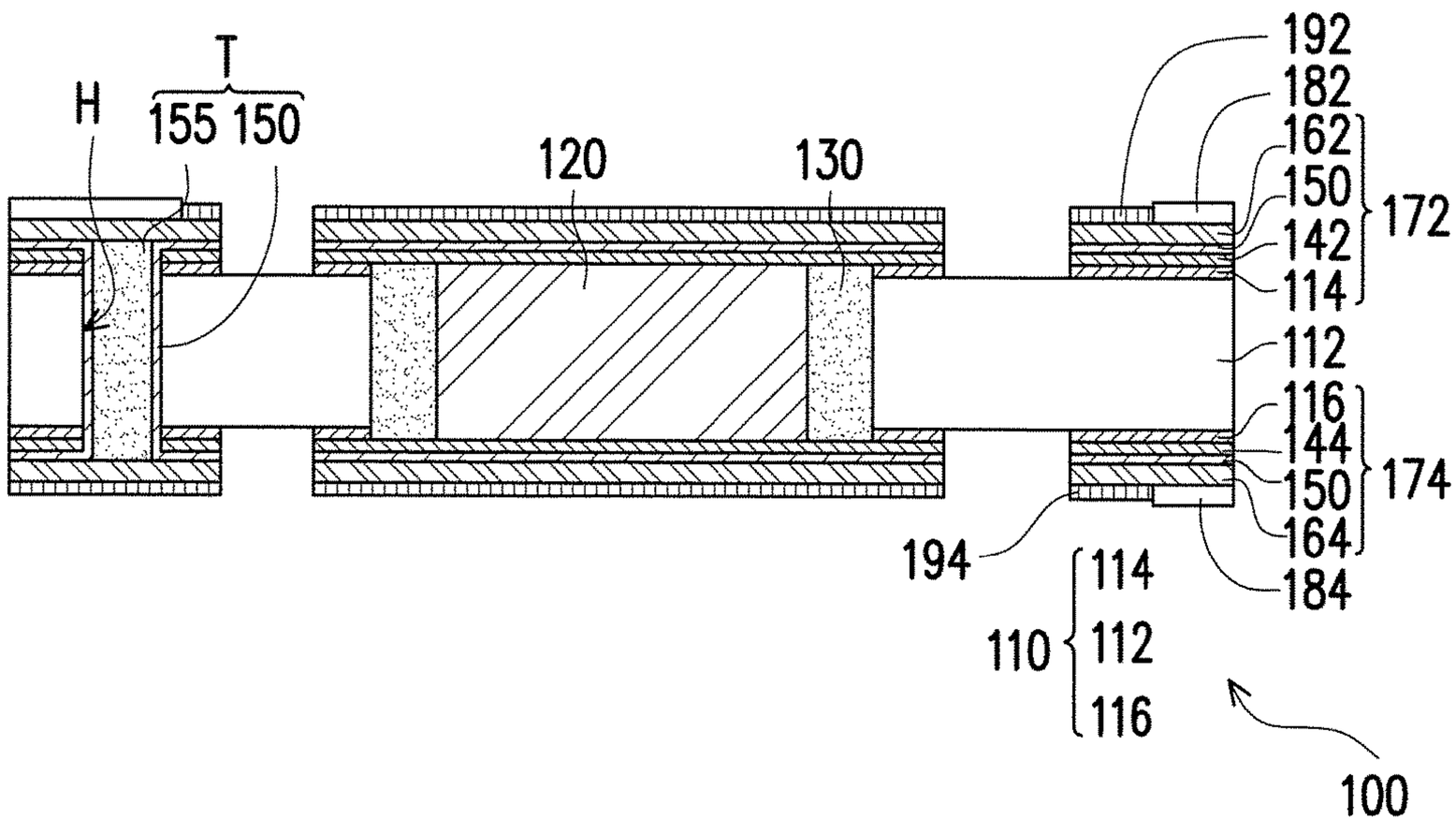
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FIG. 1M

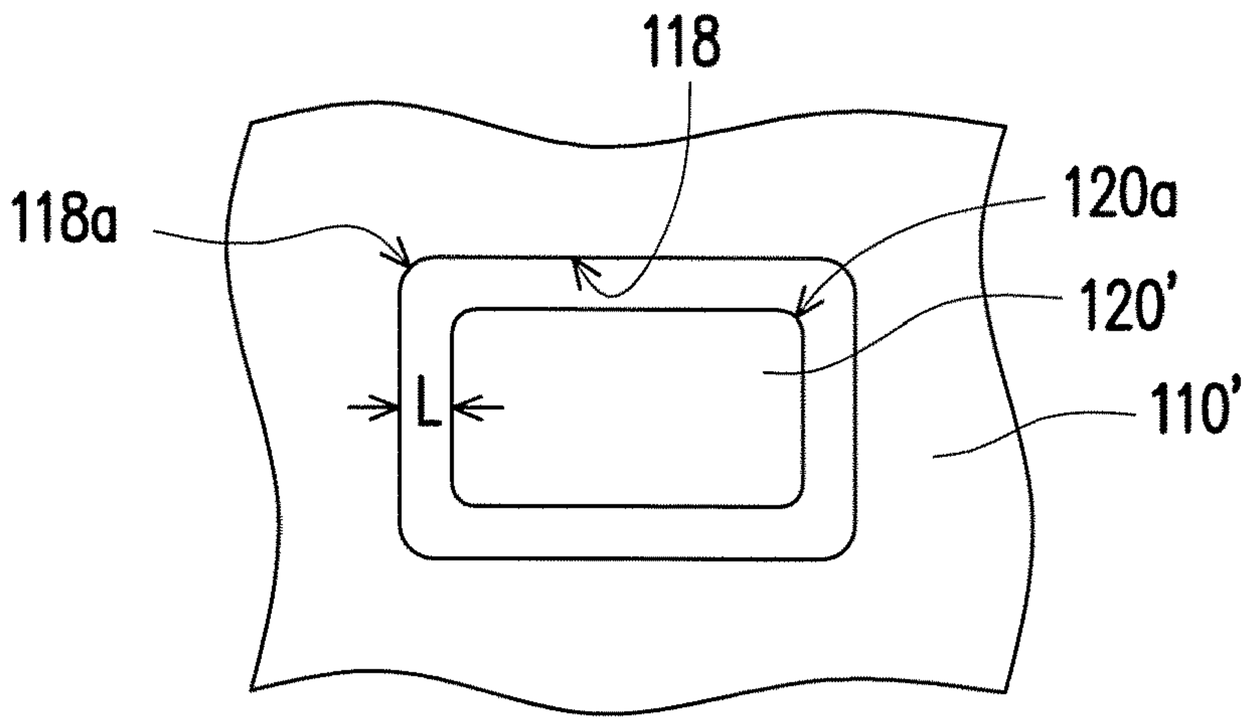

FIG. 2

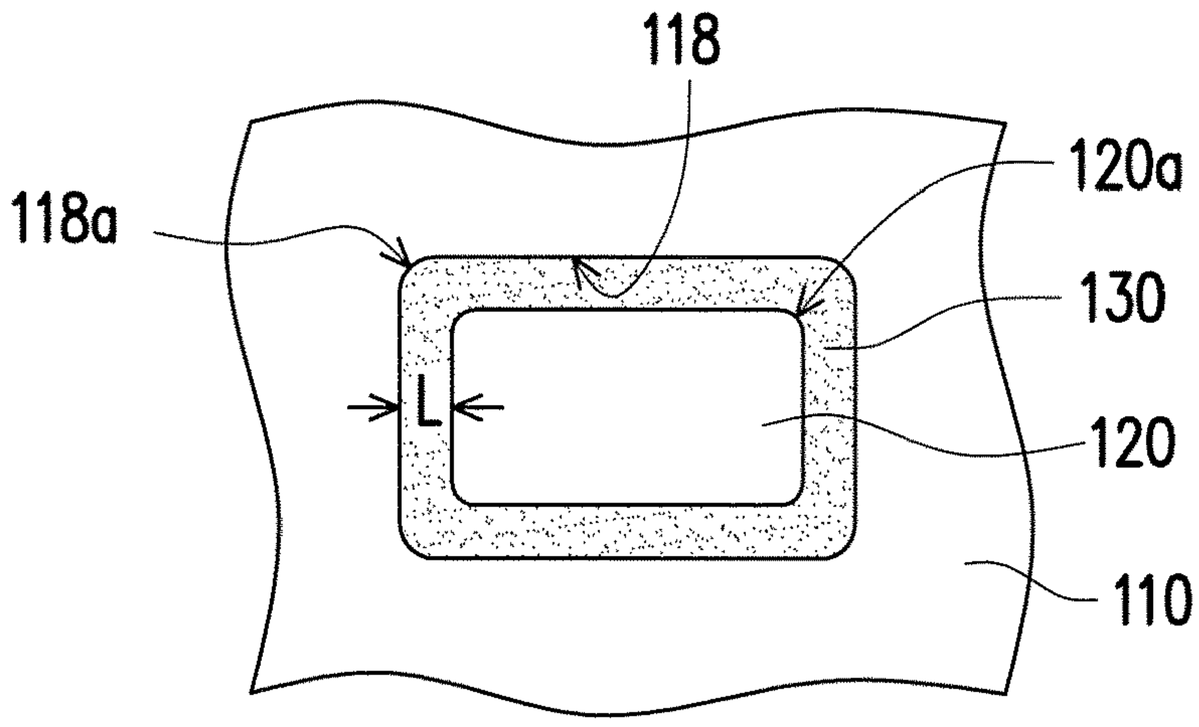

FIG. 3

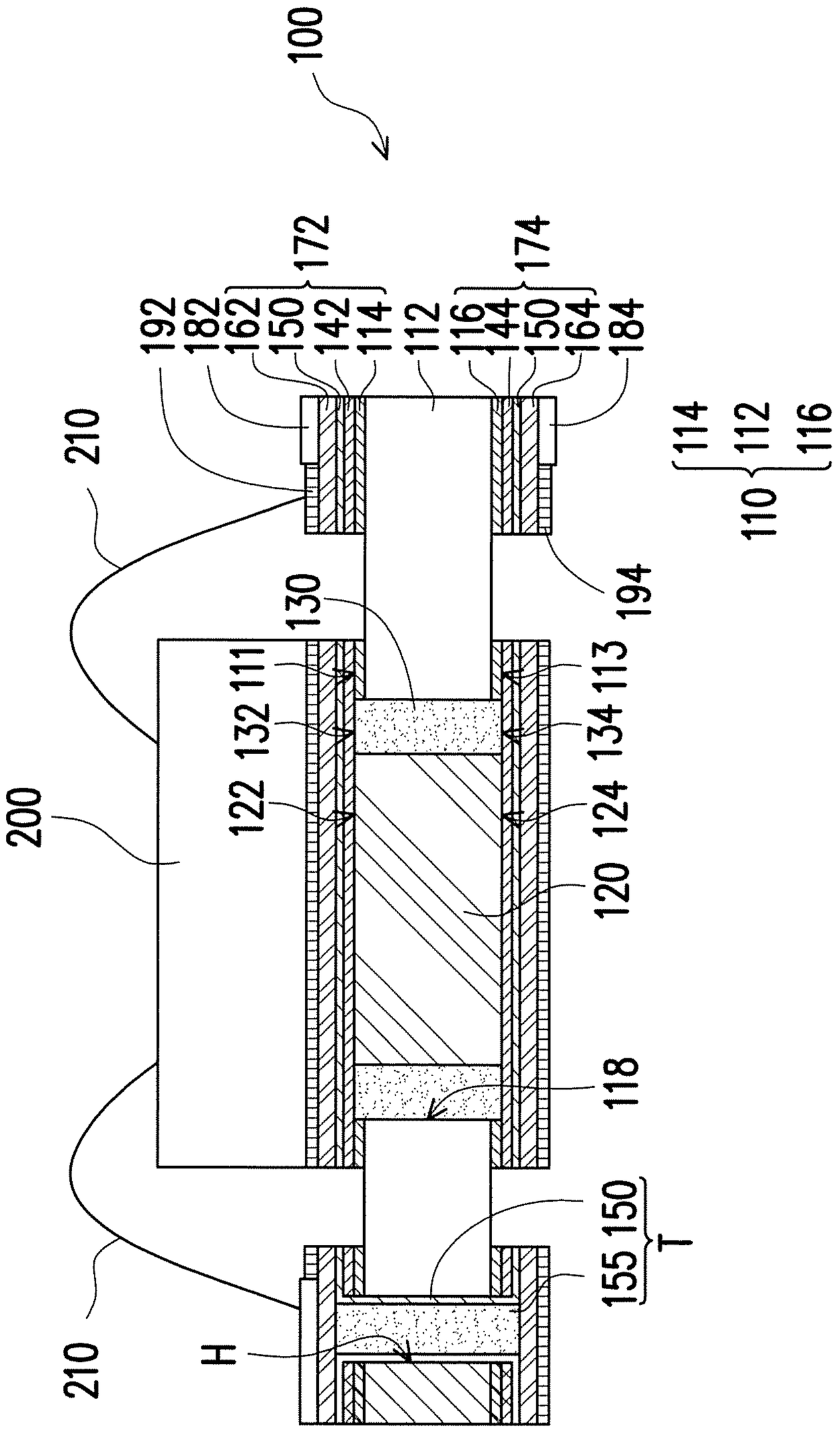
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FIG. 4

MANUFACTURING METHOD OF PACKAGE CARRIER

CROSS-REFERENCE TO RELATED APPLICATION

This application is a divisional application of and claims the priority benefit of U.S. application Ser. No. 14/932,974, filed on Nov. 5, 2015, now pending, which claims the priority benefit of Taiwan application serial no. 104130925, filed on Sep. 18, 2015. The entirety of each of the above-mentioned patent applications is hereby incorporated by reference herein and made a part of specification.

BACKGROUND OF THE INVENTION

Field of the Invention

The present invention relates to a package structure and a method for manufacturing the same, and particularly relates to a package carrier and a method for manufacturing the same.

Description of Related Art

In general, the heat conducting slug is embedded inside the package carrier in order to effectively enhance the heat conducting effect of the package carrier. Herein, the hole used to embed the heat conducting slug of the package carrier is manufactured by mechanical routing process or laser routing process, and therefore the profile of the hole from top view is easily formed as a rounded rectangular. The heat conducting slug is manufactured by etching process and laser cutting process, and therefore the profile of the heat conducting slug from top view is a right angle rectangular. Hence, stress is concentrated at the sharp corner of the heat conducting slug or the sharp corner of the heat conducting slug leans against the rounded corner of the hole so that the heat conducting slug cannot be positioned inside the hole. Furthermore, the production process of the heat conducting slug is also long because of etching process, and simultaneously the disadvantage that the cutting quality is inconsistent is generated because of laser cutting process. In addition, when the heat conducting slug is embedded inside the package carrier, in order to prevent the hole used to embed the heat conducting slug of the package carrier from interfering with the heat conducting slug, the gap between the hole and the heat conducting slug needs being greater than 200 micrometers, so as to affect the circuit layout of the package carrier. Therefore, how to narrow the gap between the hole and the heat conducting slug and to increase the density of the circuit layout is an urgent issue that needs being solved.

SUMMARY OF THE INVENTION

The invention provides a package carrier having a higher density circuit layout and a better structural reliability.

The invention also provides a manufacturing method of the package carrier, which is adapted to manufacture the above-mentioned package carrier.

The invention provides the manufacturing method of the package carrier, which includes following steps. A substrate having a through hole is provided, wherein a profile of the through hole from top view is a first rounded rectangular. A heat conducting slug is disposed inside the through hole of the substrate, wherein the heat conducting slug and an inner wall of the through hole are separated with a gap, and a profile of the heat conducting slug from top view is a second rounded rectangular. The through hole of the substrate is filled with an insulating material so as to fix the heat conducting slug in the through hole via the insulating material. A conductive through hole structure, a first patterned circuit layer and a second patterned circuit layer are formed. The first patterned circuit layer and the second patterned circuit layer are respectively formed on two opposite sides of the substrate and expose a portion of the substrate. The conductive through hole structure penetrates the substrate and connects a portion of the first patterned circuit layer and a portion of the second patterned circuit layer.

In one embodiment of the invention, a radius of a curvature of the first rounded rectangular is greater than or equal to 1 times of the gap.

In one embodiment of the invention, the heat conducting slug is formed by a punch-pressing process, and a radius of a curvature of a rounded corner of the second rounded rectangular is from 50 micrometers to 500 micrometers.

In one embodiment of the invention, the radius of the curvature of the first rounded rectangular is from 100 micrometers to 500 micrometers.

In one embodiment of the invention, the manufacturing method of the package carrier further comprises: a grinding process is performed to remove a portion of the substrate, a portion of the insulating material, and a portion of the heat conducting slug after filling the through hole of the substrate with the insulating material and before forming the conductive through hole structure, the first patterned circuit layer, and the second patterned circuit layer, so that a top surface and a bottom surface opposite to each other of the heat conducting slug are substantially coplanar with a first surface and a second surface opposite to each other of the insulating material respectively, and substantially coplanar with an upper surface and a lower surface opposite to each other of the substrate respectively.

In one embodiment of the invention, the steps forming the conductive through hole structure, the first patterned circuit layer, and the second patterned circuit layer comprise: a first metal layer and a second metal layer are formed, wherein the first metal layer covers the upper surface of the substrate, the first surface of the insulating material, and the top surface of the heat conducting slug, and the second metal layer covers the lower surface of the substrate, the second surface of the insulating material, and the bottom surface of the heat conducting slug. A passing hole is formed, which penetrates through the first metal layer, the substrate, and the second metal layer. Forming a seed layer on the first metal layer, an inner wall of the passing hole, and the second metal layer. The passing hole is filled with a filling material to form the conductive through hole structure, wherein the seed layer is located between the filling material and the inner wall of the passing hole, and a third surface and a fourth surface opposite to each other of the filling material are substantially coplanar with a fifth surface and a sixth surface opposite to each other of the seed layer respectively. A third metal layer and a fourth metal layer are formed, wherein the third metal layer covers the fifth surface of the seed layer and the third surface of the filling material, and the fourth metal layer covers the sixth surface of the seed layer and the fourth surface of the filling material. A patterning process is performed to pattern the third metal layer, the seed layer, and the first metal layer so as to form the first patterned circuit

layer, and to pattern the fourth metal layer, the seed layer, and the second metal layer so as to form the second patterned circuit layer.

In one embodiment of the invention, the manufacturing method of the package carrier further comprises: a first solder mask layer and a second solder mask layer are formed after forming the conductive through hole structure, the first patterned circuit layer, and the second patterned circuit layer. The first solder mask layer is disposed on the first patterned circuit layer and exposes a portion of the first patterned circuit layer, and the second solder mask layer is disposed on the second patterned circuit layer and exposes a portion of the second patterned circuit layer. A first surface treatment layer and a second surface treatment layer are formed. The first surface treatment layer is disposed on the first patterned circuit layer exposed by the first solder mask layer, and the second surface treatment layer is disposed on the second patterned circuit layer exposed by the second solder mask layer.

The package carrier of the invention includes a substrate, a heat conducting slug, an insulating material, a first patterned circuit layer, a second patterned circuit layer, and a conductive through hole structure. The substrate has a through hole, wherein a profile of the through hole from top view is a first rounded rectangular. The heat conducting slug is disposed inside the through hole of the substrate, wherein the heat conducting slug and an inner wall of the through hole are separated with a gap, and a profile of the heat conducting slug from top view is a second rounded rectangular. The insulating material is disposed inside the through hole of the substrate so as to fix the heat conducting slug in the through hole via the insulating material. The first patterned circuit layer is disposed on one side of the substrate. The second patterned circuit layer is disposed on another side of the substrate. The conductive through hole structure penetrates the substrate and connects a portion of the first patterned circuit layer and a portion of the second patterned circuit layer.

In one embodiment of the invention, a radius of a curvature of the first rounded rectangular is greater than or equal to 1 times of the gap.

In one embodiment of the invention, the heat conducting slug is formed by a punch-pressing process, and a radius of a curvature of a rounded corner of the second rounded rectangular is from 50 micrometers to 500 micrometers.

In one embodiment of the invention, the radius of the curvature of the first rounded rectangular is from 100 micrometers to 500 micrometers.

In one embodiment of the invention, a top surface and a bottom surface opposite to each other of the heat conducting slug are substantially coplanar with a first surface and a second surface opposite to each other of the insulating material respectively, and substantially coplanar with an upper surface and a lower surface opposite to each other of the substrate respectively.

In an embodiment of the invention, the package carrier further includes a first solder mask layer and a second solder mask layer. The first solder mask layer is disposed on the first patterned circuit layer and exposes a portion of the first patterned circuit layer. The second solder mask layer is disposed on the second patterned circuit layer and exposes a portion of the second patterned circuit layer.

In an embodiment of the invention, the package carrier further includes a first surface treatment layer and a second surface treatment layer. The first surface treatment layer is disposed on the first patterned circuit layer exposed by the first solder mask layer. The second surface treatment layer is disposed on the second patterned circuit layer exposed by the second solder mask layer.

Based on the above, the profile of the heat conducting slug of the invention from top view is the rounded rectangular, so as to prevent the problem that stress concentration is generated at the corners of the heat conducting slug, and to improve the structural reliability of the package carrier. In addition, the profiles of the heat conducting slug and the through hole of the substrate from top view are the same (the rounded rectangular), and therefore the heat conducting slug does not generate structural interference when positioning inside the through hole of the substrate, so that the heat conducting slug can be accurately positioned inside the through hole to improve the structural reliability of the package carrier.

In order to make the aforementioned and other features and advantages of the invention more comprehensible, embodiments accompanying figures are described in detail belows.

BRIEF DESCRIPTION OF THE DRAWINGS

The accompanying drawings are included to provide further understanding, and are incorporated in and constitute a part of this specification. The drawings illustrate exemplary embodiments and, together with the description, serve to explain the principles of the invention.

FIG. **1**A to FIG. **1**M are cross-sectional schematic views depicting a manufacturing method of a package carrier of one embodiment of the invention.

FIG. **2** is a partial schematic top view depicting a heat conducting element disposed inside a through hole of a substrate corresponding to FIG. **1**D.

FIG. **3** is a partial schematic top view depicting an insulating material disposed inside a through hole of a substrate corresponding to FIG. **1**E.

FIG. **4** is a cross-sectional schematic view depicting the package carrier carrying a heat generating element corresponding to FIG. **1**M.

DESCRIPTION OF THE EMBODIMENTS

FIG. **1**A to FIG. **1**M are cross-sectional schematic views depicting a manufacturing method of a package carrier of one embodiment of the invention. FIG. **2** is a partial schematic top view depicting a heat conducting element disposed inside a through hole of a substrate corresponding to FIG. **1**D. FIG. **3** is a partial schematic top view depicting an insulating material disposed inside a through hole of a substrate corresponding to FIG. **1**E. According to the manufacturing method of the package carrier, firstly, referring to FIG. **1**A, providing a substrate **110'**. The substrate **110'** of the present embodiment can be, for example, a single layer circuit board, a double layer circuit board, or a multi-layer circuit board. Herein, as shown in FIG. **1**A, the substrate **110'** is a double layer circuit board which is constructed by a dielectric layer **112** and circuit layers **114'**, **116'** located at two opposite sides of the dielectric layer **112**, but the invention is not limited thereto.

Subsequently, referring to the FIG. **1**B and FIG. **2** simultaneously, forming a through hole **118** which penetrates through the dielectric layer **112** and the circuit layers **114'**, **116'** of the substrate **110'**, wherein a profile of the through hole **118** from top view is a first rounded rectangular **118***a*. Herein, the method for forming the through hole **118** is, for example, punching, routing, mechanical drilling, laser drilling, or other appropriate methods, which are not limited by

the invention. The radius of the curvature of the first rounded rectangular **118***a* is, for example, greater than or equal to 1 times of the gap L, or the radius of the curvature can be, for example, from 1.5 times to 15 times of the gap L, but the invention is not limited thereto. Preferably, the radius of the curvature of the first rounded rectangular **118***a* is from 100 micrometers to 500 micrometers. The gap L is, for example, from 50 micrometers to 500 micrometers. The above-mentioned scope is used for description and the invention is not limited thereto.

Subsequently, referring to FIG. **1**C, an adhesive layer AD is disposed on one side of the substrate **110'**, wherein the adhesive layer AD and the through hole **118** of the substrate **110'** define an accommodating space S. It should be noted here, the adhesive layer AD is only adhered to one side of the substrate **110'** temporarily to serve as a supporting element for a subsequent heat conducting element **120'**.

Subsequently, referring to FIG. **1**D and FIG. **2**, disposing a heat conducting slug **120'** inside the through hole **118** of the substrate **110'** and in the accommodating space S, wherein a gap L is in between the heat conducting slug **120'** and the inner wall of the through hole **118**, and a profile of the heat conducting slug **120'** from top view is a second rounded rectangular **120***a*. The heat conducting slug **120'** of the present embodiment is formed by a punch-pressing process, and therefore the peripheral corners of the heat conducting slug **120'** are all rounded corners, so as to prevent the conventional problem that stress concentration is generated at the right angle corners of the heat conducting slug. After that, the heat conducting slug **120'** in the present embodiment is formed by the punch-pressing process, therefore, the production is at a fast rate and the process stability is high, so as to prevent the product quality from being varied, and to improve the product yield. Preferably, the radius of the curvature of the rounded corner of the second rounded rectangular **120***a* is from 50 micrometers to 500 micrometers, herein, the material of the heat conducting slug **120'** is, for example, metal such as copper, copper alloys, aluminum, aluminum alloys, titanium, titanium alloys, etc., but it is not limited thereto.

Subsequently, filling the through hole **118** of the substrate **110'** with an insulating material (not shown) so as to fix the heat conducting slug **120'** in the through hole **118** of the substrate **110'** via the insulating material. At this time, the heights of the thickness of the insulating material and the thickness of the heat conducting slug **120'** are all higher than the surface of the circuit layer **114'**, and the accommodating space S is filled up with the insulating material and the heat conducting slug **120'**. Herein, the method for filling the through hole **118** of the substrate **110'** with the insulating material is, for example, vacuum screen printing, but not be limited thereto. In addition, the material of the insulating material is, for example, resin or glue, but not be limited thereto. Subsequently, removing the adhesive layer AD (referring to FIG. **1**D), so as to expose the heat conducting slug **120'** and the circuit layer **116'**. Herein, the method for removing the adhesive layer AD is a mechanical stripping method.

Subsequently, Referring to the FIG. **1**E, FIG. **1**F, and FIG. **3** simultaneously, in order to have a better surface flatness, a grinding process is performed to remove a portion of the substrate **110'**, a portion of the insulating material, and a portion of the heat conducting slug **120'**, so as to form the insulating material **130**, the heat conducting slug **120**, and the substrate **110** having the circuit layers **114**, **116**, and the dielectric layer **112**. At this time, a top surface **122** and a bottom surface **124** opposite to each other of the heat conducting slug **120** are substantially coplanar with a first surface **132** and a second surface **134** opposite to each other of the insulating material **130** respectively, and substantially coplanar with an upper surface **111** and a lower surface **113** opposite to each other of the substrate **110** respectively.

Subsequently, referring to FIG. **1**F, forming a first metal layer **142** and a second metal layer **144**, wherein the first metal layer **142** covers the upper surface **111** of the substrate **110**, the first surface **132** of the insulating material **130**, and the top surface **122** of the heat conducting slug **120**, and the second metal layer **144** covers the lower surface **113** of the substrate **110**, the second surface **134** of the insulating material **130**, and the bottom surface **124** of the heat conducting slug **120**. Herein, the material of the first metal layer **142** and the second metal layer **144** is, for example, copper, copper alloys, aluminum, aluminum alloys, titanium, titanium alloys, etc., but it is not limited thereto.

Subsequently, referring to FIG. **1**G, forming a passing hole H, wherein the passing hole H penetrates through the first metal layer **142**, the substrate **110**, and the second metal layer **144**. Herein, the method for forming the passing hole H is, for example, punching, routing, mechanical drilling, laser drilling, or other appropriate methods, which are not limited by the invention.

Subsequently, referring to FIG. **1**H, forming a seed layer **150** on the first metal layer **142**, an inner wall of the passing hole H, and the second metal layer **144**. Herein, the material of the seed layer **150** is, for example, copper, or conductive materials such as conducting polymer, which are not limited by the invention.

Subsequently, referring to FIG. **1**I, filling the passing hole H with a filling material **155** to form a conductive through hole structure T. At this time, the seed layer **150** is located between the filling material **155** and the inner wall of the through hole **118**, and a third surface **157** and a fourth surface **159** opposite to each other of the filling material **155** are substantially coplanar with a fifth surface **152** and a sixth surface **154** opposite to each other of the seed layer **150** respectively. In addition, the conductive through hole structure T is constructed by the seed layer **150** and the filling material **155**. Herein, the material of the filling material **155** is, for example, resin or glue.

Subsequently, referring to FIG. **1**J, forming a third metal layer **162** and a fourth metal layer **164**, wherein the third metal layer **162** covers the fifth surface **152** of the seed layer **150** and the third surface **157** of the filling material **155**, and the fourth metal layer **164** covers the sixth surface **154** of the seed layer **150** and the fourth surface **159** of the filling material **155**. Herein, the material of the third metal layer **162** and the fourth metal layer **164** is, for example, copper, etc.

Subsequently, referring to FIG. **1**K, performing a patterning process to pattern the third metal layer **162**, the seed layer **150**, the first metal layer **142** and a portion of the substrate **110** (the circuit layer **114**) so as to form the first patterned circuit layer **172**, and to pattern the fourth metal layer **164**, the seed layer **150**, the second metal layer **144**, and a portion of the substrate **110** (the circuit layer **116**) so as to form the second patterned circuit layer **174**. At this time, as shown in FIG. **1**K, the first patterned circuit layer **172** and the second patterned circuit layer **174** are respectively formed on two opposite sides of the substrate **110** and expose a portion of the substrate **110**, and the conductive through hole structure T penetrates the substrate **110** and connects a portion of the first patterned circuit layer **172** and a portion of the second patterned circuit layer **174**.

After that, referring to FIG. **1**L, optionally forming a first solder mask layer **182** and a second solder mask layer **184**, wherein the first solder mask layer **182** is disposed on the first patterned circuit layer **172** and exposes a portion of the first patterned circuit layer **172**, and the second solder mask layer **184** is disposed on the second patterned circuit layer **174** and exposes a portion of the second patterned circuit layer **174**.

After that, referring to FIG. **1**M, in order to maintain the structural properties of the exposed first patterned circuit layer **172** and the exposed second patterned circuit layer **174**, forming a first surface treatment layer **192** and a second surface treatment layer **194**, wherein the first surface treatment layer **192** is disposed on the first patterned circuit layer **172** exposed by the first solder mask layer **182**, and the second surface treatment layer **194** is disposed on the second patterned circuit layer **174** exposed by the second solder mask layer **184**. The material of the first surface treatment layer **192** and the second surface treatment layer **194** in the present embodiment is, for example, nickel, palladium, gold, or alloys of the said materials, so as to prevent the first patterned circuit layer **172** and the second patterned circuit layer **174** from being oxidized or being subject to the external contamination. So far, the package carrier **100** is completely manufactured.

In above structure, referring to FIG. **1**M, the package carrier **100** of the present embodiment includes the substrate **110**, the heat conducting slug **120**, the insulating material **130**, the first patterned circuit layer **172**, the second patterned circuit layer **174**, and the conductive through hole structure T. The substrate **110** has a through hole **118**, wherein a profile of the through hole **118** from top view is a first rounded rectangular **118***a* (as shown in FIG. **2**), preferably, the radius of the curvature of the rounded corner of the first rounded rectangular **118***a* is from 100 micrometers to 500 micrometers. The heat conducting slug **120** is disposed inside the through hole **118** of the substrate **110**, wherein the heat conducting slug **120** and the inner wall of the through hole **118** are separated with a gap L (referring to FIG. **2**), and the profile of the heat conducting slug **120** from top view is a second rounded rectangular **120***a*. In one embodiment of the invention, the radius of the curvature of the first rounded rectangular **118** is greater than or equal to 1 times of the gap L. Preferably, the heat conducting slug **120** is formed by a punch-pressing process, and the radius of the curvature of the second rounded rectangular **120***a* is from 50 micrometers to 500 micrometers. The insulating material **130** is disposed inside the through hole **118** of the substrate **110** so as to fix the heat conducting slug **120** in the through hole **118** via the insulating material **130**. At this time, the top surface **122** and the bottom surface **124** opposite to each other of the heat conducting slug **120** are substantially coplanar with the first surface **132** and the second surface **134** opposite to each other of the insulating material **130** respectively, and substantially coplanar with the upper surface **111** and the lower surface **113** opposite to each other of the substrate **110** respectively. The first patterned circuit layer **172** is disposed on one side of the substrate **110**, and the second patterned circuit layer **174** is disposed on another side of the substrate **110**. The conductive through hole structure T penetrates the substrate **110** and connects a portion of the first patterned circuit layer **172** and a portion of the second patterned circuit layer **174**.

In addition, the package carrier **100** in the present embodiment can optionally include the first solder mask layer **182**, the second solder mask layer **184**, the first surface treatment layer **192**, and the second surface treatment layer **194**. The first solder mask layer **182** is disposed on the first patterned circuit layer **172** and exposes a portion of the first patterned circuit layer **172**, and the second solder mask layer **184** is disposed on the second patterned circuit layer **174** and exposes a portion of the second patterned circuit layer **174**. The first surface treatment layer **192** is disposed on the first patterned circuit layer **172** exposed by the first solder mask layer **182**, and the second surface treatment layer **194** is disposed on the second patterned circuit layer **174** exposed by the second solder mask layer **184**.

The profile of the heat conducting slug **120** of the present embodiment from top view is the rounded rectangular, so as to prevent the problem that stress concentration is generated at the corners of the heat conducting slug **120**, and to improve the structural reliability of the package carrier **100**. Furthermore, the profiles of the heat conducting slug **120** and the through hole **118** of the substrate **110** from top view are the same (the rounded rectangular), and therefore the heat conducting slug **120** does not generate structural interference when positioning inside the through hole **118** of the substrate **110**, so that the heat conducting slug can be accurately positioned inside the through hole, so as to improve the structural reliability of the package carrier **100**. Otherwise, in the subsequent application, referring to FIG. **4**, a heat generating element **200** can be disposed on the package carrier **100** and correspondingly configured above the heat conducting slug **120**, and the heat generating element **200** is electrically connected to the package carrier **100** by using a joining or a wire bonding method, such as bonding a plurality of wires **210**. As a result, the heat generated by the heat generating element **200** transfers rapidly and directly from the first surface treatment layer **192**, the first patterned circuit layer **172**, the heat conducting slug **120**, the second patterned circuit layer **174**, and the second surface treatment layer **194** to the external environment, so that the package carrier **100** in the present embodiment can have a better heat conducting effect.

In summary, the profile of the heat conducting slug of the invention from top view is the rounded rectangular, so as to prevent the problem that stress concentration is generated at the corners of the heat conducting slug, and to improve the structural reliability of the package carrier. In addition, the profiles of the heat conducting slug and the through hole of the substrate from top view are the same (the rounded rectangular), and therefore the structural interference that the heat conducting slug cannot be positioned inside the through hole is not generated when the heat conducting slug is positioned inside the through hole of the substrate, so that the heat conducting slug can be accurately positioned inside the through hole to improve the structural reliability and the product yield of the package carrier.

Although the present invention has been described with reference to the above embodiments, it will be apparent to one of the ordinary skill in the art that modifications to the described embodiments may be made without departing from the spirit of the invention. Accordingly, the scope of the invention is defined by the attached claims not by the above detailed descriptions.

What is claimed is:

1. A manufacturing method of a package carrier, comprising:

providing a substrate having a through hole, wherein a profile of the through hole from top view is a first rounded rectangular;

disposing a heat conducting slug inside the through hole of the substrate, wherein the heat conducting slug and an inner wall of the through hole are separated with a

gap, and a profile of the heat conducting slug from top view is a second rounded rectangular;

filling the through hole of the substrate with an insulating material so as to fix the heat conducting slug in the through hole via the insulating material;

forming a conductive through hole structure, a first patterned circuit layer and a second patterned circuit layer, wherein the first patterned circuit layer and the second patterned circuit layer are respectively formed on two opposite sides of the substrate and expose a portion of the substrate, the conductive through hole structure penetrates the substrate and connects a portion of the first patterned circuit layer and a portion of the second patterned circuit layer, and

performing a grinding process to remove a portion of the substrate, a portion of the insulating material, and a portion of the heat conducting slug after filling the through hole of the substrate with the insulating material and before forming the conductive through hole structure, the first patterned circuit layer, and the second patterned circuit layer, so that a top surface and a bottom surface opposite to each other of the heat conducting slug are substantially coplanar with a first surface and a second surface opposite to each other of the insulating material respectively, and substantially coplanar with an upper surface and a lower surface opposite to each other of the substrate respectively.

2. The manufacturing method of the package carrier as recited in claim **1**, wherein a radius of a curvature of the first rounded rectangular is greater than or equal to 1 times of the gap.

3. The manufacturing method of the package carrier as recited in claim **1**, wherein the heat conducting slug is formed by a punch-pressing process, and a radius of a curvature of the second rounded rectangular is from 50 micrometers to 500 micrometers.

4. The manufacturing method of the package carrier as recited in claim **1**, wherein a radius of a curvature of the first rounded rectangular is from 100 micrometers to 500 micrometers.

5. The manufacturing method of the package carrier as recited in claim **1**, further comprising:

forming a first solder mask layer and a second solder mask layer after forming the conductive through hole structure, the first patterned circuit layer, and the second patterned circuit layer, wherein the first solder mask layer is disposed on the first patterned circuit layer and exposes a portion of the first patterned circuit layer, and the second solder mask layer is disposed on the second patterned circuit layer and exposes a portion of the second patterned circuit layer; and

forming a first surface treatment layer and a second surface treatment layer, wherein the first surface treatment layer is disposed on the first patterned circuit layer exposed by the first solder mask layer, and the second surface treatment layer is disposed on the second patterned circuit layer exposed by the second solder mask layer.

6. The manufacturing method of the package carrier as recited in claim **1**, wherein steps forming the conductive through hole structure, the first patterned circuit layer and the second patterned circuit layer comprise:

forming a first metal layer and a second metal layer, wherein the first metal layer covers the upper surface of the substrate, the first surface of the insulating material, and the top surface of the heat conducting slug, and the second metal layer covers the lower surface of the substrate, the second surface of the insulating material, and the bottom surface of the heat conducting slug;

forming a passing hole, penetrating through the first metal layer, the substrate, and the second metal layer;

forming a seed layer on the first metal layer, an inner wall of the passing hole, and the second metal layer;

filling the passing hole with a filling material to form the conductive through hole structure, wherein the seed layer is located between the filling material and the inner wall of the passing hole, and a third surface and a fourth surface opposite to each other of the filling material are substantially coplanar with a fifth surface and a sixth surface opposite to each other of the seed layer respectively;

forming a third metal layer and a fourth metal layer, wherein the third metal layer covers the fifth surface of the seed layer and the third surface of the filling material, and the fourth metal layer covers the sixth surface of the seed layer and the fourth surface of the filling material; and

performing a patterning process to pattern the third metal layer, the seed layer, and the first metal layer so as to form the first patterned circuit layer, and to pattern the fourth metal layer, the seed layer, and the second metal layer so as to form the second patterned circuit layer.

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